Program-Level Trends in Energy R&D

This section reviews cross-country patterns and trends in each of four major energy R&D program areas: fossil energy, energy efficiency, renewable energy, and nuclear energy.

Fossil Energy R&D –Fossil energy R&D programs in industrialized countries no longer focus, as they did a decade or more ago, on research to locate and characterize new fossil energy resources and to develop new methods of cheaply extracting these resources. To a large extent, fossil energy R&D programs are also moving away from the development of "clean coal" technology programs designed to improve the efficiency and cleanliness of fossil fuel combustion. The beginning of a potentially significant transition in fossil energy research programs is now discernible, wherein programs are seeking to develop zero carbon dioxide emitting fossil fuel technologies. Amid this transition, technologies that are receiving increasing emphasis include methods to "decarbonize" fossil fuels, programs to develop fuel cells capable of making use of the resulting hydrogen-rich fuel streams, and methods to sequester carbon dioxide. Another noteworthy trend is the expansion of fossil fuel research efforts to investigate the potential for developing new, plentiful, and relatively clean hydrocarbon resources such as methane hydrates and coal bed methane reservoirs. Although these non-conventional programs are currently small, their emergence signals an expansion of the concept of fossil fuels and an expectation of the continued viability of fossil fuels, even under greenhouse gas constraints, well into the next century. The Netherlands and Japan have for example had longstanding research programs examining the efficacy of new fossil energy technologies such as carbon sequestration. Of the countries surveyed, Japan is the largest supporter of these advanced fossil energy research programs (e.g., carbon sequestration, methane hydrates).[1]

Renewable Energy R&D – In recent years, the focus of industrialized countries' renewable energy R&D programs has become more concentrated in the area of solar photovoltaics. Wind energy technology research also receives significant support although it appears that the primary objective of wind energy R&D programs is on technology deployment and commercialization, rather than on the development of new systems and components that would fundamentally improve the efficiency or economics of wind power systems. Interestingly, Japan continues to fund renewable energy technology programs that no longer receive funding from the other countries such as wave/ocean power and waste-to-energy systems. Also, the Japanese government funds a relatively large amount of geothermal research given the abundance of geothermally active sites in Japan. Perhaps the most significant trend in renewable energy research is the relatively flat budgets of these programs throughout the course of the 1990s, a decade that saw increasing rhetoric from national governments pledging to do their best to reduce carbon dioxide emissions through, in part, the increased use of renewable energy systems.

Energy Efficiency –Funding for energy efficiency programs has experienced the most consistent growth of all technology areas. In the United States, for example, public

[1] Monastersky, Richard. "The Ice that Burns: Can methane hydrates fuel the 21st century?" Science News. November 14, 1998

energy efficiency R&D has increased by 53% since 1990. Similarly, while Germany's consolidated energy efficiency and renewable R&D budget has grown only slightly over the past decade, its percentage of the total energy R&D budget has grown since 1985 from 9% to 39%. The Netherlands' efficiency programs have also grown steadily, now accounting for some 38% of the Dutch public energy R&D budget. Industrial energy efficiency programs appear to be receiving preference for R&D funds over buildings or transportation-related energy efficiency programs. This preference for industrial energy efficiency R&D likely reflects both a desire to improve competitiveness and to protect the environment.[2]

Nuclear Energy R&D – The future of nuclear energy and related technologies is in a period of uncertainty in many countries. Many nations are decidedly shifting an ever-larger share of their fission energy R&D programs away from the development of new reactors and components to focus on research activities concerned with the nuclear fuel cycle, waste disposal, and reactor decommissioning. In Germany and the United States, for example, the fission research budgets have fallen in real terms by more than 90% over the past decade. With respect to fusion research, Congress' withdrawal of support for U.S. participation in the International Thermonuclear Experimental Reactor (ITER) project and the change in focus of the domestic program from "fusion energy technology development" to "fusion energy sciences" indicates that the commercial availability of fusion energy is still on the distant horizon.

Are Current Energy R&D Investments Sufficient?

The governments of most industrialized countries have set out to tighten energy efficiency standards as a primary means of reducing carbon dioxide emissions. For example, Japan has officially stated that there will need to be lifestyle changes, some of which are likely to be "painful" to Japanese citizens. The Japanese government is setting ambitious industrial energy efficiency targets, for instance by requiring all auto manufacturers to surpass the efficiency of the current industry leader within ten years. On the other hand, in the United States, it has been suggested that major emissions reductions could be achieved at no cost through the aggressive deployment of new energy efficiency technologies and the creation of an international carbon permit trading regime.[3] While in the Netherlands, the government has estimated that attaining an emission reductions goals such as those of the Kyoto Protocol would require annual increases in energy efficiency of approximately 2%, which could entail investments of $1-2 billion per year.

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[2] See Bundesministerium fur Bildung, Wissenschaft, Forschung, und technologie, *4. Programm Energieforschung und Energietechnologien* (Bonn: BMBF, 1997), p. 10; European Commission, EC Research Funding (Luxembourg: Office for Official Publications of the European Communities, 1996), p. 15.

[3] Interlaboratory Working Group. 1997. *Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy –Efficient and Low-Carbon Technologies by 2010 and Beyond* (Berkeley, CA: Lawrence Berkeley National Laboratory and Oak Ridge, TN: Oak Ridge National Laboratory), LBNL-40533 and ORNL-444, September (URL address: http://www.ornl.gov/ORNL/Energy_Eff/CON444), Executive Summary.

Despite major differences across countries in political culture and choices of policy instruments, countries share an assumption that greater energy efficiency will carry them a significant part of the way toward realizing the major carbon emissions reductions in the future. This policy trend raises questions about the prospects for future government support for new, advanced energy technology programs.

To a larger extent than has occurred in the United States, government and industry in Japan and Europe have come to a shared view of climate change as presenting potential economic opportunities. In the Netherlands, for example, renewable energy technologies are seen as holding great potential as a future export industry. In the estimation of these governments, climate change provides an impetus for the establishment of international standards for "clean energy technologies" and potential opportunities for those who set the standards to dominate energy technology markets.[4] Although there are American companies that have adopted similar views, the highly polarized political environment in the United States with regard to climate change has thus far prevented the government and industry from consolidating its position to the extent that European countries and Japan have.

Government funding for renewable energy research is increasingly aimed at helping industry to reduce the costs of energy production using renewable technologies, thereby helping to improve the commercial viability of these technologies. Public funding in this area is aimed principally at improving existing technologies and facilitating their introduction to the market rather than developing new renewable energy technologies. Although the costs of energy from renewable sources has declined significantly over the past decade, renewables face an ongoing challenge in many countries in an era of energy deregulation. The introduction of competition in the electricity industry is reducing the costs of conventionally-generated electricity, effectively neutralizing many of renewable energy sources' recent economic gains and thereby making it more difficult for renewables to expand its share of the electricity generation market.

There is also mounting evidence that the ongoing deregulation of the energy industries in many countries is exerting downward pressure on energy R&D activities, particularly in the private sector (see Dooley, 1998). While deregulation often leads to positive outcomes such as lower energy prices and more choice for consumers, the competitive dynamics it introduces also heightens managers' and shareholders' sensitivity to short-term market performance indicators. The pressures on private sector energy firms to reduce costs increasingly compel them to reduce their levels of R&D expenditure and to focus their remaining R&D investments on shorter-term, product-oriented projects.

By "privatizing" the governance of the energy industries through deregulation, governments redefine the roles of the public and private sectors in providing energy

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[4] Jacob Park and Paul Runci. "Energy After Kyoto: Opportunities and Challenges for the United States, Japan, and Germany," Workshop Report. Workshop sponsored by the University of Maryland's Harrison Program on the Future Global Agenda and the Mitsubishi International Corporation. College Park, MD. January 30, 1998.

services to the public. Although privatization may bring higher levels of economic efficiency in the energy industries, those gains may compromise the ability to take a long view with regard to the energy future and to invest accordingly in energy R&D.

Summary and Next Steps

This report represents a snapshot of progress made in the initial phase over the course of a few months. The data contained in this report and the conclusions drawn from this report should be viewed as provisional and subject to future revision in response to additional data and comments from peer reviewers. Moreover, as we move to develop the next set of case studies for Canada, France, Italy, Switzerland and the United Kingdom, we will be in a position to better judge the true magnitude and significance of the changes in the industrialized nations' support for energy R&D.

One particularly interesting question we will address in the next phase of this project is the extent to which these smaller energy R&D performing nations are now starting to specialize in the development of particular energy technologies. For example, we will seek to assess the extent to which key countries might be moving away from their previous strategy of support for a broad energy R&D portfolio that would be capable of addressing a wide range of future contingencies, and toward R&D portfolios that are more specialized and oriented toward a smaller range of energy technologies. It is likely, for example, that problems of public perception and economics might make fission energy R&D susceptible to deep budget cuts, as has already occurred in the United States and Germany. The development of such trends merits further investigation and analysis.

In addition to carrying out an analysis of some of the energy R&D programs of these other nations, we intend to make use of economic models such as the Edmonds' MiniCAM and Second Generation Models (see Edmonds, et al., 1997) to assess these national and the aggregate OECD energy R&D portfolios *vis a vis* the particular energy policy goal of climate change. For example, Dooley, Edmonds, and Wise (1998) have shown that the continued development of carbon capture and disposal technologies could reduce the cost of stabilizing atmospheric concentrations of carbon dioxide by more than 35%. The potential cost savings associated with the further development and deployment of these technologies could be on the order of hundreds of billions of dollars.

As we conclude the first phase of this project, we are concerned with an energy technology gap that appears likely to emerge in the midterm. Carbon dioxide disposal, methane hydrates, and nuclear fusion are long-term energy technology prospects likely to become commercially available in the latter half of the next century, while the deployment of today's "advanced" energy efficiency technologies will help achieve some of the more immediate energy policy goals of the present. A key, and still open, questions remains that of the sufficiency of current funding flows for the development of technologies needed in the intervening period to stabilize carbon dioxide levels in the Earth's atmosphere. We will continue to pursue answers to this question and to assess the adequacy of current R&D efforts in the second phase of this research project.